Hospital re-admission in patients with acute exacerbation of chronic obstructive pulmonary disease

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Abstract A retrospective study was carried out in a Hong Kong regional hospital with 24-h emergency service, to study the factors associated with shorter time to re-admission after acute exacerbation of chronic obstructive pulmonary disease (COPD). From 1 January 1997 to 31 December 1997, the first admission (index admission) of each patient through the emergency room with COPD/chronic bronchitis/emphysema was included. A total of 551 patients fulfilled the inclusion criteria. The total acute and rehabilitative length of stay (mean $\pm$ SD) was 9·41 $\pm$ 11·67 days. Within 1 year after discharge, 327 patients (59·35%) were re-admitted at least once. Median time to first re-admission after discharge was 240 days. By Cox regression analysis, the following factors were independently associated with shorter time to re-admission: hospital admission within 1 year before index admission, total length of stay in index admission >5 days, nursing home residency, dependency in self-care activities, right heart strain pattern on electrocardiogram, on high dose inhaled corticosteroid and actual bicarbonate level >25 mmol l^{-1}. These factors may be relevant in the future planning of healthcare utilization for COPD patients.

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Keywords re-admission; exacerbation; chronic obstructive pulmonary disease; COPD.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is defined as a disease state characterized by the presence of airflow obstruction due to chronic bronchitis or emphysema (1). It is a chronic debilitating illness which gives rise to significant morbidity and frequent hospital admissions. In the United States, the overall prevalence of COPD in the adult white population is 4–6% in men and 1–3% in women. In persons older than 55 years, COPD is recognized in approximately 10–15% (2,3). In Hong Kong, a 1991–1992 survey of the prevalence of respiratory symptoms and diseases was performed in 2032 (999 males) elderly ($\geq$70 years) Chinese by interviews and questionnaires. Chronic bronchitis and emphysema were found to be present in 6·85% and 2·4% of subjects respectively (4). In 1996, COPD ranked first in the list of discharge diagnoses from the medical units of 11 Hong Kong Hospital Authority hospitals offering emergency room service.

Because COPD is so common, studies on the pattern of hospital utilization may be useful to assist health service planning. In the following study, we aimed to identify factors associated with shorter time to first re-admission after discharge from hospital following treatment of an acute exacerbation. We hypothesized that such factors could be readily obtained at the time of a patient's admission.

METHODS

A retrospective study of COPD admissions to the medical unit of Pamela Youde Nethersole Eastern Hospital (PYNEH), Hong Kong, through the emergency room for acute COPD exacerbation from 1 January 1997 to 31 December 1997 was performed using patient chart abstraction. PYNEH served a population of 600 000 at the time of the study and is one of the three regional hospitals in Hong Kong Island offering 24-h emergency room service. The first hospitalization for COPD exacerbation of each patient within the study period, defined as the

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index admission, was identified by a statistician from the Hong Kong Hospital Authority from its territory-wide computer database using the International Classification of Diseases 9th Revision Clinical Modification (ICD-9-CM) coding. The database also tracked all admission episodes before and after the index admission if the study patients were admitted to any hospital under the Hong Kong Hospital Authority, which serves about 93% of hospitalized patients in Hong Kong. The following codes as the primary or secondary discharge diagnosis were identified: 491·21 (obstructive chronic bronchitis with acute exacerbation), 492 (emphysema) and 496 (chronic airway obstruction, not classified elsewhere). Patients were included if (a) their primary discharge diagnoses were one of the above codes or if (b) the primary discharge diagnoses were 480 (viral pneumonia), 481 (pneumococcal pneumonia), 482 (other bacterial pneumonia), 483 (pneumonia due to other specified organism), 485 (bronchopneumonia), 486 (pneumonia, organism unspecified); and the secondary diagnoses were 491·21, 492 or 496. These criteria should include most patients with COPD exacerbations due to chest infection, pneumonia, or other unspecified causes. Exclusion criteria were: (a) exacerbations due to pneumothorax, (b) co-existing pulmonary diseases which may predict early re-admission (asthma, bronchiectasis, restrictive lung diseases including significant fibrosis or destroyed lung due to old pulmonary tuberculosis, kyphosis, interstitial lung disease), (c) lung cancer diagnosed within 3 months before the index admission or currently on chemotherapy, (d) pulmonary tuberculosis on treatment, and (e) death in index admission. Past and subsequent admissions were also subject to the same inclusion and exclusion criteria. Doctors in the emergency room and medical wards were not aware of this study.

Data collection was performed by two authors (A.C.W.L., E.P.). Information on the index admission was obtained from notes by physicians, nurses, physiotherapists, occupational therapists and social workers. In particular, the admission 'nursing cardex', which contained detailed information on smoking status and history, occupation, marital status, home care and welfare support status, self-care abilities, and use of long term oxygen therapy, was an important and reliable source of data. Variables analysed included (a) demographic data (age, sex, number of admissions before and after index admission, dates of index admission and discharge, acute and rehabilitative lengths of stay in index admission, date of first re-admission after discharge from index admission), (b) social data (smoking status, occupation, marital status, home care and social welfare status, self-care ability in activities of daily living), (c) lung function data (best peak expiratory flow rate in index admission), (d) non-pulmonary co-morbidities [presence of chronic atrial fibrillation or multifocal atrial tachycardia, right heart strain pattern on electrocardiogram (EKG), diabetes mellitus, coronary artery disease, left ventricular failure], (e) results of first blood test in index admission (haemoglobin, total white blood cell count, creatinine, albumin, pH, PCO_2, actual bicarbonate), (f) past treatment (long-term oxygen therapy, high dose inhaled or systemic corticosteroid). Baseline $P\mathrm{aO}_2$ values were not analysed because many of these patients had already been given oxygen supplement before blood gases were checked.

Definitions of selected variables are as follows: dependence or requirement of assistance in activities of daily living = dependent/required assistance in at least one of the following activities: mouth-washing, bathing, feeding, grooming, toileting, walking; presence of right heart strain on EKG = EKG evidence of p pulmonale (p wave axis $\geq 90^{\circ}$), right bundle branch block or absent or marginal increase of R wave amplitude from V_1 to V_6 leads. Treatment with high dose inhaled corticosteroid = $\geq 1000\,\mu g$ beclomethasone-equivalent per day for ≥ 3 months before the date of index admission. Treatment with high dose systemic corticosteroid = $\geq$ 15 mg prednisolone-equivalent per day for $\geq$ 3 months before the date of index admission. Cut-off points to define long-term high dose inhaled and systemic corticosteroids are arbitrary, however, they represent the dosages above which significant side-effects might occur.

Statistical analysis

Relationship between patient characteristics and time to first re-admission was analysed by Kaplan–Meier analysis. Absence of re-admission within 1 year after discharge from the index admission was taken as censored status. Independent factors associated with shorter time to first re-admission after discharge were identified by incorporating those factors with log-rank test P-values $< 0{\cdot}05$ into a Cox proportional hazards regression model using forward step-wise entry. Statistical analysis was carried out using SPSS® version 9.

RESULTS

In 1997, 760 patients admitted for COPD exacerbation into the medical unit of PYNEH were identified. Information was incomplete in 27 patients and they were excluded. Another 182 patients did not fulfill the inclusion criteria: exacerbations due to pneumothorax (six patients), one or more co-existing pulmonary diseases as listed [142 patients: asthma (85), restrictive lung diseases (29), bronchiectasis (28)], lung cancer (10 patients), active pulmonary tuberculosis (five patients) and death in index admission (19 patients). Demographic and characteristics of the 551 patients included in the final analysis are shown in Table 1. The majority of patients were unemployed/retired males with a smoking history.

TABLE 1. Demographic and clinical characteristics of 551 COPD patients

Variable	Mean ± standard deviation (% total number of patients)
Demographic data and lung function	
Age	73·75 ± 8·59 (median 75, range 45–100)
Male sex	426 (77·3%)
Smoking status	
Non-smoker	20 (3·6%)
Ex-smoker	384 (69·7%)
Active smoker	147 (26·7%)
Occupation	
Professional	1 (0·2%)
Skilled	12 (2·2%)
Unskilled/semi-skilled	22 (4·0%)
Unemployed/retired	516 (93·6%)
Best peak expiratory flow rate ($l\,min^{-1}$)	
< 100	79 (14·3%)
100 – 200	254 (46·1%)
> 200	113 (20·5%)
Not done	105 (19·1%)
Total length of stay (days)	9·41 ± 11·67 (median 5, range 0–104)
Acute	4·05 ± 4·16 (median 3, range 0–34)
Rehabilitative	5·36 ± 10·64 (median 0, range 0–103)
Results of first blood test after admission	
Haemoglobin ($g\,dl^{-1}$)	12·89 ± 1·78
Total white blood cell count ($\times 10^9\,ml^{-1}$)	9·58 ± 4·22
Creatinine ($\mu m\,l^{-1}$)	89·00 ± 33·59
Albumin ($g\,l^{-1}$)	39·03 ± 4·60
pH	7·38 ± 0·06
PaCO_2 (mm Hg)	44·72 ± 12·71
Actual bicarbonate ($mmol\,l^{-1}$)	25·74 ± 5·01

By the end of 1 year after individual dates of discharge from the index admissions, 327 (59·35%) patients had been re-admitted at least once. The median time to first re-admission was 240 days [95% confidence interval (CI) 204–276 days, Fig. 1]. The relationship between patient characteristics and time to first readmission was analysed by Kaplan–Meier analysis and is shown in Table 2. The following factors were associated with shorter time to first re-admission after discharge from index admission: age >75 years, hospital admission within 1 year before index admission, length of stay in index admission >5 days, nursing home residency, dependency/requirement for assistance in self-care activities, right heart strain pattern on EKG, coronary artery disease, left ventricular failure, on long-term oxygen therapy, on high dose inhaled corticosteroid, on high dose systemic corticosteroid, PaCO_2 >50 mmHg and actual bicarbonate level >25 $mmol\,l^{-1}$. Figure 2(a)–(d) is bar-charts showing the mean ± SEM of the percentage of patients not yet re-admitted within 1 year after discharge from index admission with respect to their demographic and social data [Fig. 2(a)], co-morbidities [Fig. 2(b)], treatment categories [Fig. 2(c)] and first blood investigation after admission [Fig 2(d)].

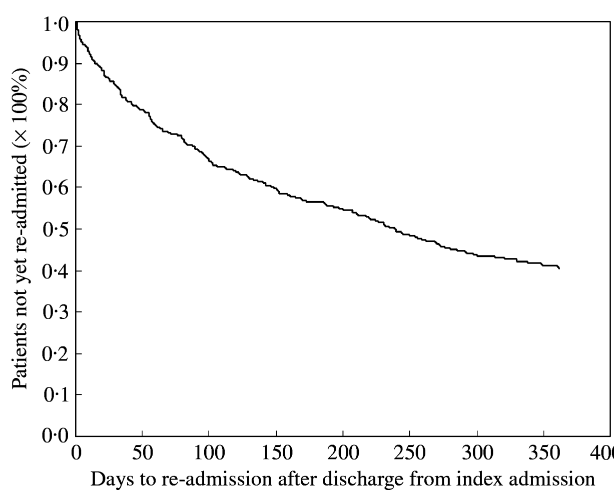


FIG. 1. Kaplan–Meier plot of time to first re-admission within 1 year after discharge from index admission (n = 551).

For Cox regression analysis, two models were set up because 54 patients did not have blood test results for

TABLE 2. Kaplan–Meier analysis of time to first re-admission within 1 year after discharge from index admission

Predictive variable	Subgroups	Number of patients	% of patients not yet re-admitted	*P*-value*
Demographic and social data				
Age, years	≤75	299	47·49 ± 2·89	0·0013
	> 75	252	32·54 ± 2·95	
Sex	M	426	41·08 ± 2·38	0·5778
	F	125	39·20 ± 4·37	
Hospital admission in previous year	Yes	194	27·32 ± 3·20	< 0·0001
	No	357	47·9 ± 2·64	
Total length of stay in index admission, day(s)	≤5	286	45·1 ± 2·94	0·0100
	> 5	265	35·85 ± 2·95	
Discharged from rehabilitation bed	Yes	259	44·4 ± 3·09	0·2679
	No	292	37·33 ± 2·83	
Marital status	Married with spouse alive	376	42·29 ± 2·55	0·1537
	Single/widowed/divorced/separated	175	37·14 ± 3·65	
On social welfare	Yes	171	37·43 ± 3·70	0·2033
	No	380	42·11 ± 2·53	
Nursing home residents	Yes	46	23·91 ± 6·29	0·0002
	No	505	42·18 ± 2·20	
Self-care ability	Dependent/required assistance	116	26·72 ± 4·11	< 0·0001
	Independent	435	44·37 ± 2·38	
Comorbidities				
Chronic atrial fibrillation or multifocal atrial tachycardia	Yes	17	29·41 ± 11·05	0·2489
	No	534	41·01 ± 2·13	
Right heart strain pattern on EKG	Yes	121	28·10 ± 4·09	0·0001
	No	430	44·19 ± 2·39	
Diabetes mellitus	Yes	37	37·84 ± 7·97	0·9461
	No	514	40·86 ± 2·17	
Coronary artery disease	Yes	46	15·22 ± 5·36	0·0008
	No	505	42·97 ± 2·20	
Left ventricular failure	Yes	28	21·43 ± 7·75	0·0216
	No	523	41·68 ± 2·16	
Treatment				
Mechanical ventilation	Yes	16	31·25 ± 11·59	0·1357
	No	535	40·93 ± 2·13	
Non-invasive ventilation only	Yes	9	22·22 ± 13·86	0·2435
	No	542	40·96 ± 2·11	
On long-term oxygen therapy	Yes	46	15·22 ± 5·30	< 0·0001
	No	505	42·97 ± 2·20	
On high dose inhaled corticosteroid	Yes	96	25·00 ± 4·42	0·0003
	No	455	43·96 ± 2·33	
On high dose systemic corticosteroid	Yes	13	15·38 ± 10·01	0·0151
	No	538	41·26 ± 2·12	
First blood investigation after admission				
Haemoglobin, (g dl^{-1})	≤15	465	40·86 ± 2·28	0·7386
	> 15	54	37·04 ± 6·57	
	Not available	32		
Total WBC count (x 10^9 ml^{-1})	≤10	338	40·83 ± 2·67	0·6988
	> 10	181	39·78 ± 3·64	
	Not available	32		
Creatinine (μml^{-1})	≤130	474	40·51 ± 2·25	0·7520
	> 130	48	43·75 ± 7·16	
	Not available	29		
Albumin (g l^{-1})	≤ 35	99	42·42 ± 4·97	0·9801
	> 35	381	39·63 ± 2·51	
	Not available	71		

TABLE 2. *(continued)*

Predictive variable	Subgroups	Number of patients	% of patients not yet readmitted	*P*-value*
pH	≤7·35	131	41·22±4·30	0·8105
	>7·35	366	41·26±2·57	
	Not available	54		
$PaCO_2$ (mmHg)	≤50	382	44·24±2·54	0·0073
	>50	115	31·30±4·32	
	Not available	54		
Actual bicarbonate (mmol l^{-1})	≤25	243	49·79±3·21	0·0004
	> 25	254	33·07±2·95	
	Not available	54		

*Log-rank test.

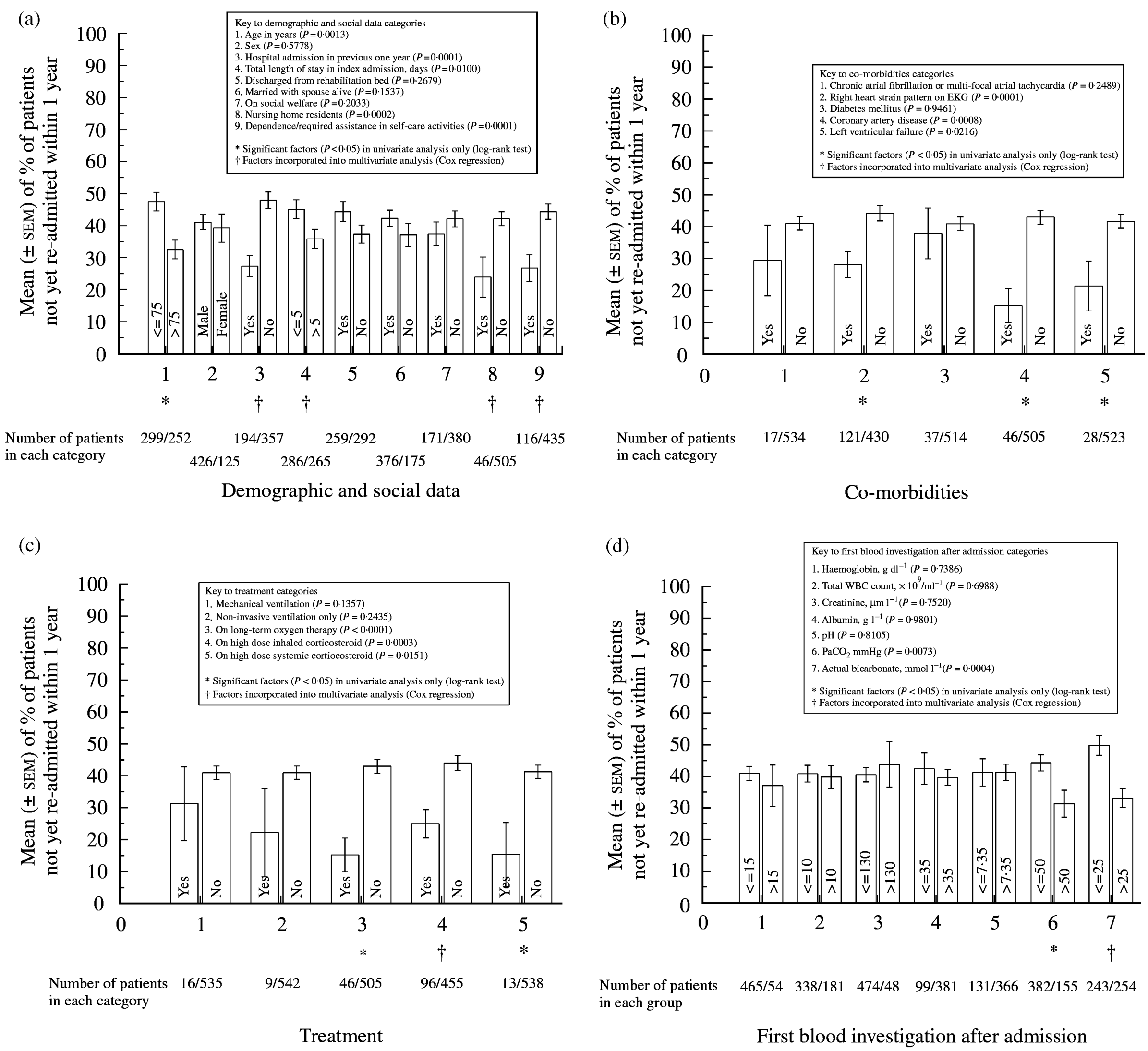


FIG. 2. Bar-charts showing the mean ±SEM of the percentage of patients not yet re-admitted within 1 year after discharge from index admission with respect to demographic and social data (a), co-morbidities (b), treatment categories (c) and first blood investigation after admission (d).

TABLE 3. Cox proportional hazards analysis of independent factors associated with shorter time to first re-admission [model 1: only patients with blood test results (n=497); model 2: all patients, blood test results not analysed (n = 551)]

Condition	Model 1		Model 2	
	Hazards ratio (95% CI)	P-value	Hazards ratio (95% CI)	P-value
Hospital admission in previous 1 year	1·553 (1·219–1·977)	< 0·001	1·509 (1·200–1·898)	< 0·001
Total length of stay in index admission > 5 days	1·403 (1·111–1·771)	0·004	1·274 (1·023–1·586)	0·030
Nursing home residency	1·718 (1·169–2·525)	0·006	1·679 (1·163–2·424)	0·006
Dependency in self-care activities	1·396 (1·062–1·835)	0·017	1·498 (1·157–1·940)	0·002
Right heart strain pattern on EKG	1·557 (1·188–2·039)	0·001	1·602 (1·248–2·056)	< 0·001
On high dose inhaled corticosteroid	1·354 (1·020–1·799)	0·036	1·374 (1·049–1·799)	0·021
Actual bicarbonate > 25 mmol l^{-1}	1·351 (1·062–1·720)	0·014		

unspecified reasons (Table 3). The first model included those patients with blood results ($n = 497$) and the second one included all patients ($n = 551$) but excluded blood results in the analysis. For model 1, the following were independent factors for shorter time to re-admission: hospital admission within 1 year before index admission, length of stay in index admission >5 days, nursing home residency, dependency in self-care activities, right heart strain pattern on EKG, on high dose inhaled corticosteroid, and actual bicarbonate level >25 mmol l^{-1}. For model 2, similar factors apart from actual bicarbonate level >25 mmol l^{-1} are found. Kaplan–Meier plots of these independent factors are shown in Fig. 3(a)–(g).

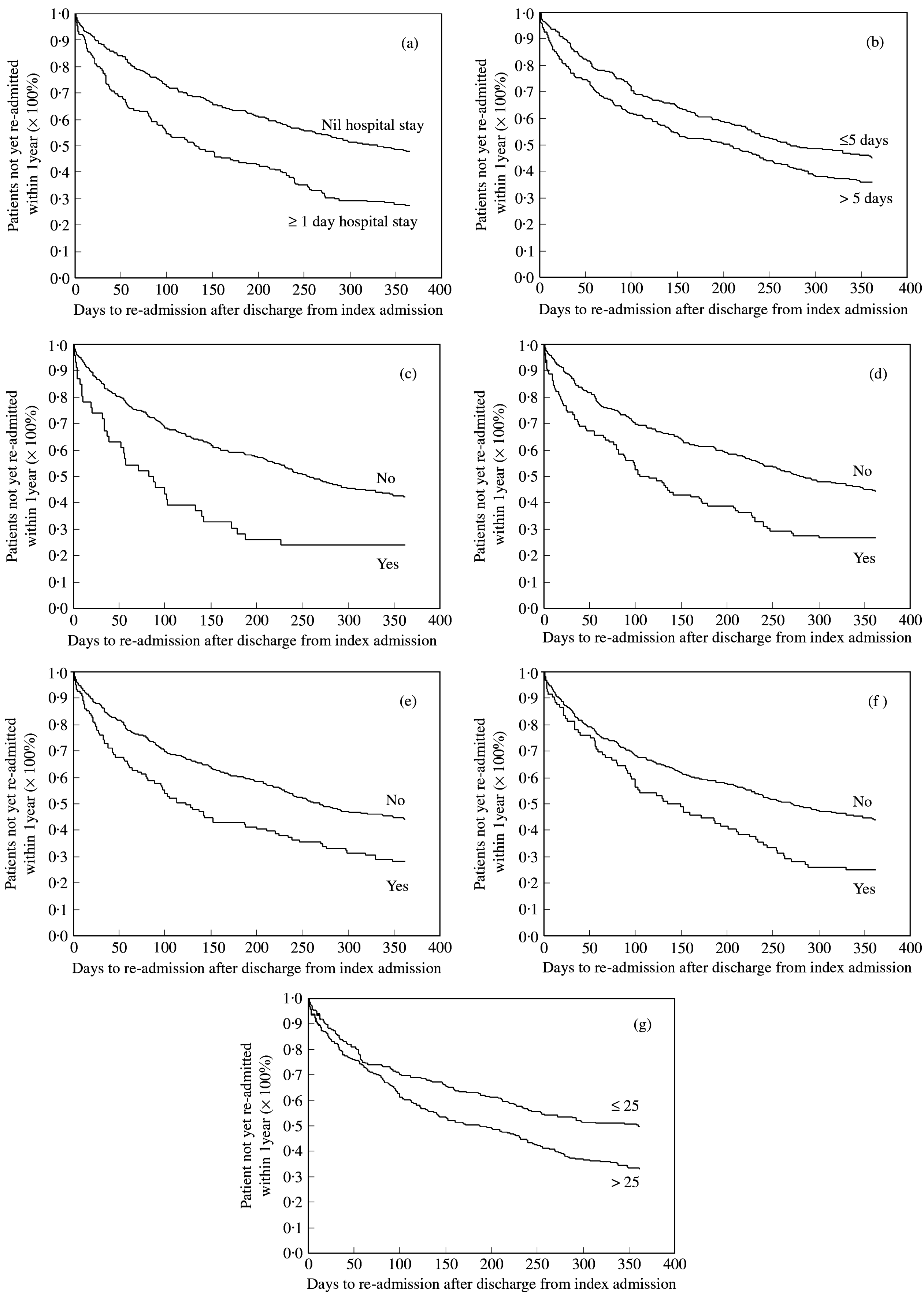
DISCUSSION

This study confirmed that re-admissions after acute COPD exacerbation were common, and that factors readily obtainable from history taking and simple investigations at the time of admission were related to timing of subsequent re-admissions.

The retrospective nature of this study has the advantage that the decision to admit or discharge was not biased by the study and the results therefore can be taken to represent the real-life situation in our hospital. However, we believe that several major factors not assessed by this study could influence its results, including the insurance system (which does not play a significant role in hospital care financing locally because 93·1% of the territory's inpatients are under the care of hospitals under government-funded Hospital Authority), socio-economical factors, physicians' subjective opinions and patients' preferences. Although data from private hospitals were not available, they are not expected to have any significant influence on the results of our data, as only 6·9% of total hospital days were being utilized in private hospitals (1998 data).

A major drawback in this study is the lack of pulmonary function data as an assessment of severity. The role of forced expiratory volume in 1 sec (FEV_1) in predicting hospital utilization is controversial (5–7). Most previous studies on COPD hospitalization did not, however, provide comprehensive information or analysis in lung function. Even in a well-designed prospective study like SUPPORT (8), only 27% of patients had pulmonary function tests performed within 1 year of admission. In our study, 19·1% did not have peak expiratory flow rate performed during their inpatient stay. Apart from a research setting, lung function testing may not be practical for various reasons in patients admitted for exacerbations, which may include problems with the ability of a sick patient to perform the maneuvre, technique of the patients, timing of performance in relation to the

FIG. 3. Kaplan–Meier plots of the independent factors associated with shorter time to first re-admission (n = 551 except in actual bicarbonate level where n = 497). The log-rank test was used for comparison. (a) Hospital re-admission in previous 1 year ($P < 0·0001$), (b) length of stay in index admission ($P < 0·0100$), (c) nursing home residency ($P < 0·0002$), (d) dependency in self-care activities ($P < 0·0001$), (e) right heart strain pattern on EKG ($P < 0·0001$), (f) on high dose inhaled corticosteroids ($P < 0·0003$, (g) actual bicarbonate level in mmol l^{-1} ($P < 0·0004$).


(a)
Nil hospital stay
≥ 1 day hospital stay
Patients not yet re-admitted within 1year (× 100%)
Days to re-admission after discharge from index admission
(b)
≤5 days
> 5 days
Patients not yet re-admitted within 1year (× 100%)
Days to re-admission after discharge from index admission
(c)
No
Yes
Patients not yet re-admitted within 1year (× 100%)
Days to re-admission after discharge from index admission
(d)
No
Yes
Patients not yet re-admitted within 1year (× 100%)
Days to re-admission after discharge from index admission
(e)
No
Yes
Patients not yet re-admitted within 1year (× 100%)
Days to re-admission after discharge from index admission
(f)
No
Yes
Patients not yet re-admitted within 1year (× 100%)
Days to re-admission after discharge from index admission
(g)
≤ 25
> 25
Patient not yet re-admitted within 1year (× 100%)
Days to re-admission after discharge from index admission

exacerbation and urgency of the need to initiate treatment. However, we believe that lung function testing is an integral component in COPD management, both to monitor the trend of exacerbations and to allow severity categorization. Further limitations of our study include the diagnostic accuracy of COPD, which depended only on the attending physicians' judgment, and also, details of drug treatment and sputum bacteriology were not available. Only information on corticosteroids was collected because these drugs are considered to have potentially significant side-effects, and there were still controversies regarding their efficacy in COPD at the time of the study. It is possible that medications other than corticosteroids, as well as the adequacy of treatment, could also influence the time to re-admission.

We have excluded other respiratory co-morbidities (asthma, bronchiectasis and restrictive lung diseases) in the analysis, because in our preliminary analysis in which we included patients with these co-morbidities, they were found to be very significant independent predictors of early re-admission in themselves, to the extent that they overshadowed the significance of other factors. Exacerbation of COPD due to other causes such as pneumothorax and acute decompensated congestive heart failure were also excluded, because they are in their own rights distinct reasons for admission independent of whether COPD is exacerbated or not, and the treatment and course of these conditions could often be easily distinguished from the usual infective or non-infective cause of COPD exacerbation. On the other hand, co-existing stable chronic left ventricular failure was found to be a factor associated with early re-admission in the study patients on univariate analysis. We believe that all these co-morbidities are important contributing factors to COPD morbidity.

PaO_2 and SpO_2 levels could vary greatly during the course of treatment with oxygen or bronchodilators. At the initial data collection, reliable data on PaO_2 and SpO_2 levels could not be obtained because documentation of the prevailing oxygen level was not complete. We have therefore decided not to include them in the final analysis.

Many previous studies have found higher total number of re-admissions or lengths of hospital stay to be related to various patient factors, including higher (worse) scores on the St George's Respiratory Questionnaire (9,10); more frequent past exacerbations, daily cough, daily wheeze, bronchitic symptoms (10); reduced quadriceps force and maximal expiration pressure (7); respiratory symptoms (cough, mucus hypersecretion, breathlessness) and FEV_1 (5,11); lower socioeconomic index, household income and education (12). The only prospective study to assess predictors of the time to first hospitalization for exacerbation of COPD was reported by Kessler *et al.* (13) in 64 stable outpatients with moderate to severe COPD. The median time to first hospital admission for acute exacerbation was 29 months (95% CI 24–33 months) after assessment, which was much longer than the 240 days in our study of inpatients. By multivariate analysis, PaCO_2 and mean pulmonary arterial pressure (measured with pulmonary artery catheter) at rest were independent predictive factors of early hospital admission. The results of our study showed possibly similar conclusion, with less invasive and indirect means, that high actual bicarbonate level (which reflects chronic hypercapnia) and right heart strain pattern on EKG (which crudely reflects underlying pulmonary hypertension complicating COPD in the patients studied) were two of the independent factors.

Abnormalities of gas exchange have therefore been found in both Kessler's and our study to be significantly related to shorter time to first admission and re-admission. It is possible that early identification of complications such as cor pulmonale and its early prevention with oxygen therapy, which had been proved to improve survival (14,15), may be important ways to reduce re-admissions. Patients with chronic hypercapnia, and hence raised actual bicarbonate, are probably more easily symptomatic than normocapnic patients because of their rapid and shallow breathing pattern (16), resulting in earlier and more frequent medical attention seeking. Indeed, use of domiciliary non-invasive positive pressure support ventilation in selected patients has been found to result in improvements in arterial blood gas tensions (17,18), reduction in both hospital admissions and general practitioner visits (17), as well as improved quality of life in chronic hypercapnic COPD patients (18).

In our study, hospital admission in the past 1 year, longer length of stay and use of inhaled corticosteroids, were also independent factors. These are likely to reflect the severity of the underlying COPD. Both inhaled and oral corticosteroids are significant factors in univariate analysis, but only inhaled corticosteroid is retained in the multivariate analysis.

Our results showed that nursing home residents were re-admitted early. Nursing home care is not well developed in Hong Kong. Although it is possible that nursing home residents could be sicker, it is our general feeling that nursing home staff tend to bring the residents to seek medical care (especially emergency room attendance) more frequently and earlier even for minor exacerbations, and these residents might therefore also be admitted more easily. Some form of outreach team care such as a respiratory home care service may help to reduce this type of admission.

Self-care ability reflects the severity of a patient's underlying illness, and is a major factor determining quality of life and self-esteem. Moreover, the stress of the caregivers may also have a bearing on earlier re-admission and may require further investigation. Home-based nursing care programmes are being studied to see if they can reduce the number of admissions or healthcare utilization, but results were mixed (19–24), probably due to different study populations and methods of intervention.

In conclusion, information obtained at the time of a COPD patient's hospital admission was related to the time to re-admission in our study. These factors may be relevant in the future planning of healthcare utilization for COPD patients. With early identification of these factors and aggressive prevention of complications, patients can be re-categorized into different levels of care and rehabilitation needs more rationally. It is hoped that re-admissions for COPD exacerbation and excessive consumption of health care resources can thus be reduced.

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